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MEHTOD FOR FABRICATING LIQUID CRYSTAL DISPLAY DEVICE

[Abstract]

PURPOSE: To execute filling work of the liquid crystal for a short time by filling the smectic liquid crystal between filled surfaces of a substrate, and simultaneously, sealing the peripheral part of a pair of substrates.

CONSTITUTION: After the liquid crystal is provided on the filled surface of one side substrate, the filled surface of other substrate is tightly connected on the liquid crystal, and further, a pair of substrates are arranged to the pre scribed mutual position. Further, as the same process as the process, the laminat ing system is used which executes the sealing for sealing to the peripheral part, especially, to the corner part of the square or rectangular substrate. As the liquid crystal material, the smectic liquid crystal, especially preferably, the ferroelectric liquid crystal to show a smectic C phase (SmC*) is used. Name ly, the interval of the cell is made into 4μ m or the interval below it is made into 0.5W3μ m, and thereby, the bistable condition can be obtained.

SPECIFICATION

1 Title of the invention

MEHTOD FOR FABRICATING LIQUID CRYSTAL DISPLAY DEVICE

2. Claims

1. A method for fabricating a liquid crystal display (LCD) device in which a pair of substrates each having an electrode are disposed such that their charge-subject surfaces face each other and liquid crystals are charged between the charge-subject surfaces, wherein smectic liquid crystals are charged between the charge-subject surfaces and an edge portion of the pair of substrates is sealed.

2. The method of claim 1, wherein sealing is performed on at least a corner portion of rectangular-shaped or square-shaped substrates.

3. A method for fabricating a liquid crystal display (LCD) device in which a pair of substrates each having an electrode are disposed such that their charge-subject surfaces face each other and liquid crystals are charged between the charge-subject surfaces, wherein smectic liquid crystals are charged between the charge-subject surfaces, a corner portion of the pair of rectangular or square substrates are sealed, and then, an edge portion of the rectangular or square substrates are sealed.

3. Detailed description of the Invention

[Field of the Invention]

The present invention relates to a method for fabricating a liquid crystal display (LCD) device and, more particularly, to a method for fabricating an LCD device capable of making a display part of a microcomputer, a word process or a TV set thin by installing a display panel using smectic liquid crystals (referred to hereinafter as 'Sm liquid crystals' or 'liquid crystals'), especially, for example, ferroelectric liquid crystals (referred to hereinafter as 'FLC').

[Description of the Prior art]

A solid display panel is effective for a large-scale display panel in controlling each pixel independently. As the solid display panel, a display device which employs a multiplexing driving method with a simple matrix structure of A4 plate size with horizontal 400 elements and vertical 200 elements by using 2 frequency liquid crystals, for example, twisted/nematic liquid crystals (referred to hereinafter as 'TN liquid crystals'), is widely known.

However, in fabricating the TN liquid crystals, since the TN liquid crystals has a low viscosity, when a pair of glass substrates are bonded, the glass substrates are placed to face with an interval of 5μ~10μ therebetween and then a sealant mixed with spacers is coated on an edge portion of the glass substrates to bond them. In this case, a portion of a seal portion of the edge portion is not sealed but remains as an opening. Thereafter, the pair of substrates with their edge portion sealed is maintained in a vacuum container and entirely vacuumized. And then, the opening is put in a TN

liquid crystal solution and the interior of the vacuum container is allowed to have an atmospheric pressure in order to charge liquid crystals into the gap of 5μ~10μ between the substrates by using a capillary phenomenon.

[Problems to be solved by the Invention]

Such method is good when liquid crystals with the low viscosity such as the TN liquid crystals are charged between the substrates at a room temperature, but has many disadvantages in the following aspects.

That is, first, the method cannot be suitably employed in terms of its operation for the smectic liquid crystals with high viscosity, for example, the FLC which uses an SmC* layer.

Second, when the FLC is used on the premise that a gap between electrodes of a cell is 4μ or less, preferably, as narrow as 0.5μ~3μ, it takes much time to charge the FLC.

Third, when the FLC is charged on a large-scale plate, for example, on the A4 plate, it take long time, namely, 8 to 10 hours, at a high temperature, i.e., 120°C for charging the FLC. Thus, sealing of the edge portion can be degraded. In addition, the sealant can be mixed as an impurity into the liquid crystals.

Fourth, spacers (generally called 'scallop') which determine the cell gap can be inclined during the process of charging the liquid crystals.

Fifth, 90% of the liquid crystal material is not effectively used during charging, resulting in a waste of liquid crystals.

The present invention solves these problems.

[Means for solving the problem]

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a method for fabricating an LCD device by using a so-called lamination method in which liquid crystals are put on one substrate, the other substrate is allowed to be tightly attached on the liquid crystals, the two substrates are mutually installed at a certain position. At the same time or in a follow-up process, sealing is made on an edge portion.

In addition, in the present invention, the smectic liquid crystals, and preferably, FLC having a smectic C phase (SmC*), are used. Namely, by making the cell gap 4μm or below, and generally, 0.5μm~3μm, a (both-side) stable state can be obtained.

That is, (isotropic) liquid crystals are dropped, spread or are coated at one or plural spots on a charge-subject surface of an electrode of one substrate. And, a small amount of sealing resin is dropped on a corner portion of one or the other substrate. Thereafter, the other substrate is placed thereon.

The substrates are vacuumized and heated at their front and back side, pressed, and tightly attached respectively with FLC with the charge-subject surface installed on the inner side of each substrate with gap of 4μm or below therebetween, and at least a portion of an edge portion is sealed simultaneously.

A temperature of the substrate on which the FLC has been charged and laminated is dropped to obtain an SmA and also the (both-side) stable SmC*. Then, a spiral structure can be released. And then, the substrates are

maintained at a room temperature and sealed with a practical plastic sealant at their edge portion.

According to the method of the present invention, a contact area between the substrates can be enlarged at their corner portion and the substrates can be more firmly bonded.

In the present invention, as for a usage temperature range, namely, the remaining problem, currently, a plurality of different FLCs can be combined (blended) and used at 0°C~50°C. Thus, the FLC can be practically used. And, referring to grey, if 8 colors are considered, the grey is not necessary, and it can be practically used for a display such as a microcomputer.

[Operation]

Accordingly, first, because a minimum cell gap is determined according to a size of spacers after spreading them, there is no non-uniformity in the gap of the formed FLC.

Second, even if the cell is thin with a gap of 4μm or below and has a large area (equivalent to A4 plate), the lamination operation can be preformed quickly.

Third, the FLC placed on the substrate can be effectively used by 100%.

Fourth, with the FLC with high viscosity, the lamination and sealing operation does not require one or more hours.

Fifth, even if an active device and an electrode connected with the active device are installed on one substrate, the FLC can be laminated in the

same manner as a process of a passive structure which does not use the active device.

With such characteristics, in the present invention, the liquid crystal laminating method (which means narrowing the gap between the two sheets of substrates and interposing the laminated liquid crystal therebetween) is employed, and the nonlinear element (NE) and the FLC are made in series to form each pixel, thereby obtaining a large-scale of A4 plate or larger matrix and driving each pixel without a cross talk therebetween.

[Embodiment of the invention]

Figure 1 illustrates a process of fabricating an LCD device in accordance with the present invention.

Figure 1A shows two substrates 1 and 1'. The substrates 1 and 1' have an electrode at the mutually facing surfaces 8 and 8' thereof. In order to display color, a color filter is installed between one electrode and the facing substrate or between one electrode and charge liquid crystals. And, as widely known, an asymmetrical alignment is performed on the surface of the electrode.

Though the two substrates are simply shown for the sake of simplification, the electrode, the filter, alignment processing, shadow processing (masking) for obtaining black matrix, and an active device can be formed or performed as necessary.

As the substrates, a glass substrate, e.g., a coning 7059, is generally used. And, among two substrates, one substrate or both substrates can be a flexible substrate. As the flexible substrate, a chemically strengthened glass

substrate with a thickness of 0.3mm~6mm or a light transmissible heat-resistant organic resin substrate such as polyimide, PAN or PET can be also effectively used.

An alignment processing layer (asymmetrical alignment processing layer) is formed on the electrode of the substrate, and its surface is subject to be charged. And then, the FLC, e.g., S8 (octyl, oxy, benziriden, amino, methyl, butyl, benzoate), is installed on the surface. Besides, an FLC such as BOBAMBC or an FLC obtained by blending a plurality of types of liquid crystals can be charged. Herein, for example, liquid crystal obtained by blending S8 and B7 is used.

In addition, liquid crystals 2 are dropped on the charge-subject surface of one substrate.

A small amount of resins 19 and 19' is dropped on a plurality of edge portions, especially, on corner portions, of the charge-subject surface of the other substrate which has been aligned downwardly. In this case, a thermosetting resin is used.

The pair of substrates with the liquid crystals installed therebetween are sealed in a vacuum container 100. The vacuum container 100 includes a first space in a container side 10 and a second space 5 in a cover side 10'. A heater 3 is installed in the first space 4. One substrate 1 is installed on the heater 3 and heated at a room temperature or at a certain temperature within 150°C, for example, at 70°C~150°C, e.g., 120°C, at which viscosity of the liquid crystals becomes sufficiently low.

Then, the liquid crystals 2 installed on the substrate 1 are heated to spread on the charge-subject surface. Before or after the liquid crystals were

dropped to be placed, spacers are installed on the substrate with a certain gap. The spacers cannot be used.

The other substrate 1' facing the substrate 1 is disposed to be separated by 1mm~10mm such that they partially contact with each other lightly.

Thereafter, the cover container 10' having the second space 5 is adjusted to the container 10 by means of an O ring. The lower portion of the second space is shielded by a layer (called a silicon rubber 6) with elasticity with respect to the second space. As for a pressure of the second space and the first space, if the pressure of the first space has a positive pressure, the lower side is expanded, whereas if the pressure of the first space is a negative pressure, the rubber 6 is pulled up. The rubber is not limited to the silicon rubber so long as it can tolerate at least the temperature of 150°C.

After they are adjusted by the O ring, they are simultaneously vacuumized at the outlets 11 and 11'. Namely, the two outlets are connected with a vacuum pump 14 after passing trough valves 12 and 12'. The first and second spaces 4 and 5 are vacuumized by opening the valves 12 and 12' and closing valves 13 and 13'.

And then, as shown in Figure 1C, the other substrate is precisely installed on the surface of the substrate. Then, the liquid crystals 3 are charged on the upper and lower charge-subject surfaces.

Subsequently, air or nitrogen is leaked gradually from the valve 13' so as to make the second space 5 have a positive pressure, compared with the first space 4, and obtain and the atmospheric pressure.

Then, as shown in Figure 1C, the silicon rubber 6 expands

downwardly to press the other substrate 1' toward the substrate 1. In the atmospheric pressure, pressure of $1kg/cm^2$ can be applied. In case of giving more pressure by using nitrogen, pressure of 1 or more and $2\sim5kg/cm^2$ can be applied.

In this manner, the uniform pressure can be applied to the entire surface of the pair of substrates, which makes liquid crystals which have been placed at one or more spots spread on the surface of the substrate 1 in the horizontal direction, so as to be laminated.

In addition, the sealant spreads on the corner portion, and both substrates are mutually attached at an area of $1\sim15mm^2$. In this case, in order for the liquid crystals at one side or the sealant at the other side not to spread beyond a predetermined position, barriers 18 and 18' formed of fiber of $1\sim3\mu m$ can be installed. The barrier can be installed over the entire peripheral regions as well as at the corner portion.

The gap between electrodes of the pair of substrates can have the uniform thickness of $4\mu m$ or less, e.g., $2\mu m$. If a spacer with a size of $2\mu m$ is previously installed, the thickness of the gap can be $2\mu m$, and if spacers of $1\mu m$ spread in advance, the thickness of the gap can be $1\mu m$.

As a matter of course, the spacer cannot be used, and liquid crystals can be laminated to a certain thickness by precisely controlling only the pressure and the heating temperature.

As a result, some liquid crystals are moved toward the edge portion. In this case, because the outer edge portion is covered by the silicon cover or blocked by the barriers 18 and 18' like a bank, overflowing of the liquid crystals outwardly of the outer edge portion of the substrate can be

substantially prevented. In addition, overflowing of liquid crystals beyond the whole edge portion or shortage of liquid crystals for covering a desired region can be prevented by precisely controlling the initial supply amount of liquid crystal material.

As for overlapping of the two sheets of substrates in the X and Y directions, the substrates can be moved to be re-installed when the liquid crystals 3 have low viscosity when it is heated with the substrates 1 and 1'.

Thereafter, the heater was gradually dropped to a room temperature in Figure 1C. In addition, the first space 5 was adjusted to have the atmospheric pressure and the cover 10' of the vacuum container 100 is taken off. A cell obtained by laminating the liquid crystals between the pair of substrates as shown in Figure 1D is taken out. The corner portion is shown, and the sealant is interposed between the two sheets of substrates to bond them.

The two sheets of facing substrates 1 and 1' have the liquid crystals 3 overlapped therebetween.

With reference to Figure 1E, a sealant 9 (generally, a plastic material) is applied to the edge portions, and then, the substrates are bonded.

As a matter of course, with reference to Figure 1A, the sealants 19 and 19' can be simultaneously dropped on the edge portion as well as on the corner portion of the rectangular or square substrates, and the entire outer edge portion can be simultaneously sealed with the laminated liquid crystals.

In this manner, the method for charging/laminating the liquid crystals with high viscosity like the smectic liquid crystals, especially, the FLC, is implemented between the substrates.

[Effect of the invention]

Accordingly, the amount of liquid crystals required to be used for one sheet of A4 plate (the area of 20cm x 30cm) can be 0.2cc enough, amounting to 2000 yen/g. That is, the liquid crystals more expensive than gold can be effectively used.

A short time, namely, about 1 hour, is taken to perform charging operation of the liquid crystals one time.

In spite of the large-scale substrate, the operation time cannot be lengthened.

That is, in the related art TN liquid crystal charging operation, the main interest is focused on not applying a stress to liquid crystals. Thus, the sealant on the edge portion of substrates support mutually with their force so as not to apply pressure, that may be applied from outside to the substrates, to liquid crystals themselves.

In this respect, however, as for the smectic liquid crystals, the inventors of the present invention have found that an external pressure applied to the liquid crystals does not matter thanks to the high viscosity of the smectic liquid crystals. Thus, such characteristics lead to accomplish the fabrication method of the present invention, which is completely different from any other related arts.

In the liquid crystal charging method in accordance with the present invention, the alignment processing layer constituting the charge-subject surface is asymmetrically aligned, namely, one portion is rubbed while the other portion is non-rubbed. In this case, after laminating, the substrates are

slightly shifted (1μ or more to 104μm) in a high temperature state according to the rubbed surface, and stress is applied to liquid crystals to align them.

As for the LCD device in accordance with the present invention, in case of a reflection type LCD device by installing a polarization plate at an outer side of one substrate or at both outer sides of the two substrates, an electrode at the side of substrate where light is made incident is made to be light-transmissible while an electrode at the other substrate is made a reflection type electrode. By having a tilt angle of the FLC as 4.5°, one sheet of filter can be installed on the substrate where light is made incident.

Meanwhile, in case of a transmission type or reflection type LCD device using two sheets of filters, two sheets of polarization plates are aligned at an outer side of each substrate and the tilt angel of the FLC is adjusted at about 22.5°. In the transmission type LCD device, a backlight unit can be irradiated by an EL (Electroluminescence) fluorescent lamp or a natural light, and the amount of transmitted light can be controlled for displaying an image.

In case of making color, preferably, a color filter is installed at an upper or lower portion of the electrode of the other substrate (namely, the substrate viewed by naked eyes).

In the present invention, a non-linear device is installed on the substrate and an electrode is installed at an upper portion of the non-linear device. Instead of the non-linear device, an active device can be used. As the non-linear device, an SCLAD (Space Charge Limitation Amorphous semiconductor Device) or an insulation gate type field effect semiconductor device having a composite diode structure such as NIN type can be used.

In the LCD device of the present invention, a photosensor using a write pen has a dot shape for displaying and reading.

The fabrication process of Figure 1 has a matrix construction of 100x100 (in case of color, 100x300).

However, the number of dots can be 640x400 (in case of color 1920x400) and 720x400, and other number of constructions.

[Description of drawings]

Figure 1 illustrates a method for fabricating a liquid crystal display (LCD) device in accordance with the present invention.

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⑤発明の名称　液晶表示装置の作製方法

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明　細　書

1.発明の名称

液晶表示装置の作製方法

2.特許請求の範囲

1.電極を互いに有する一対の基板の被充塡面を内側にして対向せしめ、前記被充塡面間に液晶を充塡した液晶表示装置の作製方法において、前記基板の被充塡面間にスメクチック液晶を充塡せしめると同時に、前記一対の基板の周辺部を封止せしめることを特徴とする液晶表示装置の作製方法。

2.特許請求の範囲第1項において、封止は長方形または正方形の基板の少なくともコーナ部に対して行うことを特徴とする液晶表示装置の作製方法。

3.電極を互いに有する一対の基板の被充塡面を内側にして対向せしめ、前記被充塡面間に液晶を充塡した液晶表示装置の作製方法において、前記基板の被充塡面間にスメクチック液晶を充塡せしめると同時に、前記一対の長方形または正方形の基板のコーナ部を封止せしめる工程と、該工程の後、長方形または正方形の基板の辺の部分に対し封止せしめることを特徴とする液晶表示装置の作製方法。

3.発明の詳細な説明

「発明の利用分野」

この発明は、液晶表示装置の作製方法に関するものであって、スメクチック液晶（以下Sm液晶または液晶という）特に例えば強誘電性液晶（以下FLCという）を用いた表示パネルを設けることにより、マイクロコンピュータ、ワードプロセッサまたはテレビ等の表示部の薄膜化を図る液晶表示装置の作製方法に関するものである。

「従来の技術」

固体表示パネルは各絵素を独立に制御する方式が大面積用として有効である。このようなパネルとして、従来は、二周波液晶例えばツウィスティック・ネマチック液晶（以下TN液晶という）を用い、横方向400素子また縦方向200素子とするA4判サイズの単純マトリックス構成にマルチプレキ

シング駆動方式を用いた表示装置が知られている。

しかし、かかるTN液晶を作製せんとした場合、このTN液晶の粘度が低いため、一対のガラス基板を5～10μの間隙をあけて対抗せしめ、この一対のガラス基板の周辺部に封止用シール剤をスペーサを混合して塗布し、お互いを密着させる。この時周辺のシール部の一部の封止をせず、開穴を残存して設けておく。この後この周辺が封止された一対の基板を真空容器内に保持し、全体を真空引きする。さらに、この後この開穴部分をTN液晶溶液中に浸し、この真空容器内を大気圧にすることにより、毛細管現象を利用して一対の基板間の5～10μの間の空隙に液晶を充塡せんとするものであった。

「発明が解決しようとする問題点」

しかしかかる方法は、TN液晶の如き室温で低粘度の液晶を基板間に充塡する場合には優れている。しかし、

(1) 粘度の高いスメクチック液晶例えばSmC*層を用いるFLC に対してはきわめて作業がしづらい。

(2) セルの電極間の間隙を4μ以下好ましくは0.5～3μの狭い間隙を用いることを前提とするFLC を用いる場合、充塡にきわめて時間がかかってしまう。

(3) FLC を大面積例えばA4版に対し充塡せんとする場合、8～10時間もの長時間高温例えば120 ℃で充塡作業を必要とする。そのため、周辺部の封止が劣化しやすい。またこの封止材料が不純物として液晶内に混入しやすい。

(4) 液晶の充塡に伴いセルギャップを決めているスペーサ（通称貝柱）が一方に偏りやすい。

(5) 充塡の際有効に用いられない液晶材料が全体の90%近くになってしまい無駄が多い。

等の多くの欠点を有する。

本発明はかかる問題点を解くものである。

「問題を解決するための手段」

かかる問題を解決するため、本発明は、一対の基板に対し液晶を充塡する前に一対の基板の周辺部をシールするのではなく、一方の基板の被充塡面上に液晶を設けた後、この液晶上に他方の基板の被充塡面を密接せしめ、さらに一対の基板を所定の相互位置に配設せしめるものである。さらにこの工程と同時工程として、周辺部特に正方形または長方形の基板のコーナ部に封止用シールを行わしめるいわゆるラミネート（薄層にする、薄層にのばすの意）方式を用いることを基本とする。

加えて本発明においては、液晶材料としてスメクチック液晶、特に好ましくはスメクチックC相(SmC*) を呈する強誘電性液晶を用いる。即ちセルの間隔を4μmまたはそれ以下の一般には0.5 ～3μmとすることにより双安定状態を得ることができる。

即ち、かかる一方の基板の電極上の被充塡面上の一点または複点に（等方性）液晶を滴下、散布またはコートする。さらに一方または他方の基板のコーナ部に封止用樹脂を微量滴下する。この後、他方の基板をこの上に配設する。

さらにこれらを真空引きをし、その前後において加熱し、その一対の基板を互いに加圧して、それぞれの基板の内側に設けられた被充塡面を4μ以下の間隙にして互いにFLC と密接せしめ、加えて周辺部の少なくとも一部を同時に封止せしめる。

さらにこの薄いFLC が充塡されラミネートされた基板の温度を降下させ、SmA を得、さらに双安定なSmC*を得る。するとらせん構造をとくことができる。この後、常温に保存した後、周辺部の辺の部分に対しシール用のプラスチック封止剤による封止を行う。

かかる本発明方法においてはこのコーナ部でお互いの基板の接触面積を多くでき、互いに固く固着させることができる。

また本発明でも残された問題点の使用温度範囲は、現在複数の異なったFLC を組合わせて(ブレンドして) 0～50℃において使用が可能となっている。このため実用上はそれほど問題とならず、また階調に関してはカラーも8色までとするならば階調が不要であり、マイクロコンピュータ等のディスプレイとしては十分実用が可能であることが判明した。

「作用」

かくすることにより、

(1) セルはスペーサを散布しその大きさにより最小の間隙を決定するため、形成されるFLC の間隙にばらつきがない。

(2) 4μ以下の間隙（セル厚）の薄いセルであっても大面積（A4版相当）であっても短時間でラミネート作業を行うことができる。

(3) 基板上に設けたFLC を100%有効利用することができる。

(4) 粘度の高いFLC を用いても、そのラミネートおよび封止の作業に1時間以上を必要としない。

(5) 一方の基板側にはアクティブ素子とそれに連結した電極を設けても、まったくアクティブ素子を用いないパッシブ構造と同一工程でFLC のラミネートができる。

さらに、これらの特徴により本発明の液晶のラミネート（2つの基板の間隙を少しづつ狭くし、その間に液晶を薄層化して介在させることを示す）

方法を用い、加えて非線型素子(NE)と強誘電性液晶(FLC) とを直列にして各画素を構成せしめる場合、A4版またはそれ以上の大面積のマトリックス化にそれぞれの画素間のクロストークを除去し駆動させることが初めて成就できた。

以下に実施例に従って本発明を説明する。

「実施例1」

第1図は本発明の液晶表示装置の作製工程を示す。

第1図(A) は2つの基板(1),(1')を有する。この相対向する面(8),(8')側にはそれぞれ電極を有している。またカラー表示をするには、その一方の側の電極と基板との間または電極と充填される液晶との間にカラーフィルタが設けられている。さらにこの電極の上面には公知の非対称配向処理がなされている。

これらの図面では、簡単にするため図示することを省略して単に基板として表記している。しかし一対の基板の相対向する側にこれらの電極、フィルタ、配向処理、ブラックマトリックス化する

シャドウ処理（マスク）の形成、アクティブ素子の作製等を必要に応じて行うことは有効である。

また、基板は一般にはガラス基板例えばコーニング7059を使用する。しかし基板の一方または双方に可曲性の基板を用いることは有効である。そしてその可曲性基板として、化学強化がなされた0.3 ～0.6mm 厚のガラス基板、またはポリイミド, PAN,PET 等の透光性耐熱性有機樹脂基板を用いることは有効である。

この基板上の電極上には配向処理層（非対称配向処理層）が設けられ、その上面を被充填面とした。そしてこの面上に、FLC 、例えばS8（オクチル・オキシ・ベンジリデン・アミノ・メチル・ブチル・ベンゾエイト）を設けた。これ以外でも、BOBAMBC 等のFLC または複数のブレンドを施したFLC を充填し得る。例えばここではS8とB7とのブレンドした液晶を用いた。

さらにこの一対の基板の一方の被充填面上に液晶(2) を滴下させた。

さらに他方の被充填面を下側に配向させた複数

の周辺部特にコーナ部にエポキシ系の封止の樹脂(19),(19')を微量に滴下した。これは熱硬化性樹脂を用いた。

かかる液晶が設けられた一対の基板を第1図(B)に示すごとき真空容器(100) に封入した。この真空容器(100) は容器側(10)に第1の空間を有し、蓋側(10') に第2の空間(5) を有する。第1の空間(4) 内にはヒータ(3) が設けられている。このヒータ(3) 上に一方の基板(1) を配設し、この基板を室温～150 ℃内の所定の温度、例えば液晶の粘度が十分低くなる70～150 ℃例えば120 ℃に加熱制御させた。すると既に基板(1) 上の被充填面に設けられた液晶(3) が加熱され被充填面に拡がる。この液晶を滴下して設ける前または後に所定の間隔をおいて基板上にスペーサを配設させた。このスペーサはまったく用いない方式をとってもよい。

さらにこの上方に対向する他方の基板(1')を1～10mm離間してまたはかるくお互いを部分的に接せしめて配置させた。

この後、この第2の空間(5) を有する蓋側容器(10') をOリングにより容器(10)側に合わせ込んだ。この第2の空間の下側には、第1の空間と第2の空間とがお互いに弾力性を有する層(以下簡単のためシリコンラバー(6) という) で遮蔽されている。そして第2の空間と第1の空間の圧力において、第1の空間の圧力が正圧の場合は下側を膨張し、逆の負圧の場合は上側に引っ張られるようになっている。このラバーは少なくとも150 ℃の温度に耐えることができる材料であれば、シリコンラバーにかぎらない。

これらをOリングにより互いに合わせ込み、(11), (11') より同時に真空引きをした。即ち、この2つの出口は、バルブ(12), (12')を経て真空ポンプ(14)に連結されている。そしてこのバルブ(12), (12') をともに開、バルブ(13), (13')をともに閉として、第1および第2の空間(4), (5) をともに真空空間とした。

さらに第1図(C) に示す如く、この上面に離間している他方の基板を精密に配設した。

すると液晶(3) は上下の被充填面に互いに充填される。加えてコーナ部の封止材(19), (19')が加熱されている基板側に接触し温度を上昇させる。そして引き続き、他方の第2の空間(5) を真空状態より第1の空間(4) に比べて正圧となるように徐々にバルブ(13') より大気または窒素をリークし大気圧にさせた。

すると第1図(C) に示す如く、シリコンラバー(6) は下側に膨張し、対向する他方の基板(1')を一方の基板(1) の側に押しつける。そして大気圧においては1kg/cm² の圧力を加えることができる。また窒素によりさらに加圧する場合は1気圧以上の2～5kg/cm²の圧力とすることも可能である。

かくして一対の基板の全表面に均一な圧力を加えることができ、この圧力により液晶は一点または複数点に点状に設けられていたが、横方向に基板(1) の表面にそって広がり、ラミネートされる。

加えて封止材もそのコーナ部で広がり、1～15mm□ の面積にてそれぞれの基板を互いに密接せしめた。

この時一方の液晶または他方の封止材が互いに混合したり、また所定の位置以上に他方により広がらないように、1～3 μの繊維よりなるバリア(18), (18')を配設しておくと有効である。またこのバリアはコーナ部のみでなく周辺全領域にわたって設けてもよい。

さらにその一対の基板の電極側の間隙は4 μ以下例えば2 μの均一な厚さとすることができる。そしてこの厚さはスペーサが2 μの大きさのものを予め配設しておくと2 μとなり、1 μのスペーサを散布させておく時には1 μとすることができる。

もちろんスペーサをまったく用いず、この圧力と加熱している温度とのみを精密に制御して所定の厚さにラミネートさせることも可能である。

その結果、液晶の余分のものは周辺部に移動する。しかしこの外周辺をシリコンラバーが覆っているため、またはバリア(18), (18')が堤防の如くにブロッキングしているため、これが基板の一部の外側周辺より外側に液晶があふれることを実質

的に防ぐことができる。またすべての外周辺より液晶があふれたり、また所望の領域全体を覆うことなく足りなくなったりすることは、初期の液晶の供給量を精密にすることにより防ぐことができる。

2つの基板のおたがいのX方向Y方向の重ね合わせは密着させる基板(1), (1')及び液晶(3) が加熱されている低粘度状態の時に移動させ再配設させることができる。

この後、第1図(C) でヒータを徐々に室温に降下した。さらに第1の空間(5) をも大気圧とし真空容器(100) の蓋(10') を取り外した。一対の基板間に液晶をラミネートさせたセルを容器より取り出し第1図(D) を作る。

この図はコーナ部を示し、封止材が2つの基板の間にも介在し、それぞれを密着させている。

かくして第1図(D) に示す如く、2つの対向する基板(1), (1')は液晶(3) を互いに実質的に重ね合わせた状態にする。

第1図(E) は周辺部の辺の部分にその後の工程

において外側より封止用シール剤(9)(一般にはプラスチック材料）を塗布し、お互いの基板を固着させる。

もちろん第1図(A) において、封止材(19),(19')は正方形または長方形の基板のコーナ部のみではなく辺となる部分に対しても同時に滴下し、外周辺のすべてを液晶のラミネイトと同時に封止をさせてもよい。

かくして、本発明のスメクチック液晶の如く、高い粘度を有する液晶、特にFLC の基板間での充塡ラミネート方法を確立することができた。

「効果」

かくすることにより、A4版(20cm ×30cmの面積）1枚で使用する液晶は0.2cc で十分であり、3000円/gと金より高価な液晶をきわめて有効に用いることができる。

1回の液晶の充塡作業を約1時間の短時間で行うことができる。

大面積になっても、作業時間は長くならないという特徴を有する。

(15)

即ち、従来より公知のTN液晶の充塡作業においては、この液晶に応力が加わらないようにすることが主である。そのため、周辺部のシール剤はおたがいの基板に外部より加わり得る圧力が液晶それ自体に加わらないよう互いの力を支えている。

しかしスメクチック液晶では、この力が液晶それ自体に加わってもその粘度が大きく、差し支えないことを本発明人は見出した。そしてこの特性を利用することにより従来とはまったく異なる本発明の如き作製方法を可能にすることができた。

以上の本発明の液晶の充塡方法において、被充塡面を構成する配向処理層を非対称配向処理とし、一方をラビング処理をし、他方を非ラビング処理とする。この時、本発明の如くラミネイトした後、この基板をラビングを施した面にそって高温状態等で微動（1μ以上の1～10⁴ μm)シフトさせ、ストレスを液晶に加え配向せしめることは有効である。

以上に述べた本発明の液晶表示装置において、この基板の一方または双方の基板の外側に偏光板

(16)

を設け，反射型とする場合は、その入射光側の電極を透光性とし、他方を反射型電極とする。そしてFLC のチルト角を約45度とすることにより、1枚のフィルタを入射光側の基板上に配設して実施することができる。

他方、2枚のフィルタを用いて透過型または反射型とする場合は、2枚の偏光板をそれぞれの基板の外側に配向させ、FLC のチルト角を約22.5度とすることにより成就させ得る。透光型においてはバックライトをEL(エレクトロ・ルミネッセンス）蛍光灯または自然光により照射し、透光する光の量を制御することによりディスプレイとすることができる。

カラー化する場合は他方の対向基板側(人間の目で見える側）の電極の上側または下側にカラーフィルタを設ければよい。

さらに本発明においては、基板上に非線型素子を配設し、その上方に電極を設けたものを基板として取扱い、アクティブ素子型とすることができる。かかる場合、この非線型素子としてNIN 型等

(17)

の複合ダイオード構造を有するSCLAD(空間電荷制限電流型アモルファス半導体装置）、絶縁ゲイト型電界効果半導体装置を用いることが可能である。

本発明の液晶表示装置において、ライトペンを用いたフォトセンサをドット状に作ることにより表示とその読み取りとを行うことができる。

本発明の第1図の作製工程は100 ×100(カラーにおいては100 ×300)のマトリックス構成とした。

しかしこのドット数は640 ×400(カラーの場合は1920×400),720×400 その他の構成をも有し得る。

5.図面の簡単な説明

第1図は本発明の液晶表示装置の作製方法を示す。

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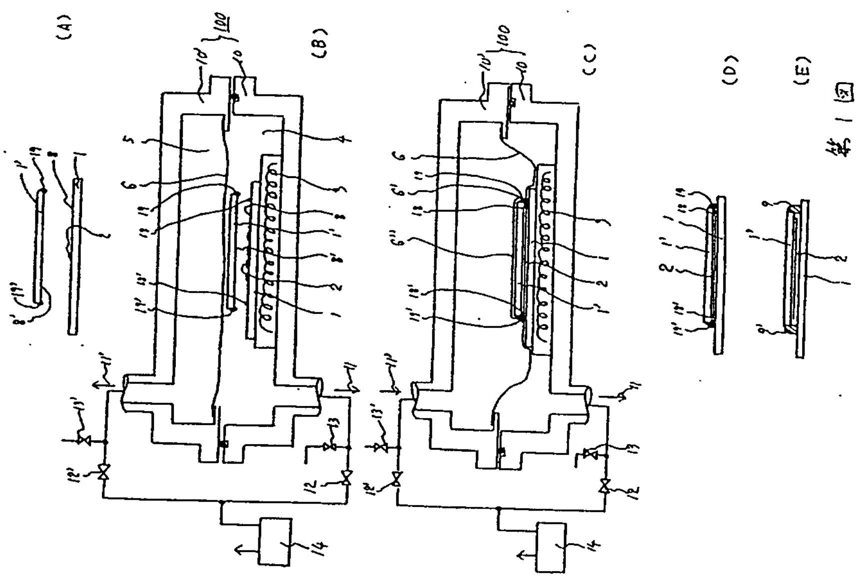
(18)



第1頁の続き

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1. Title of the Invention

LIQUID CRYSTAL DISPLAY PANEL AND METHOD OF FABRICATING THE SAME

2. Scope of Claims

(1) A liquid crystal display panel using at least one of two or more electrode substrates in common, the panel in which the electrode substrates are disposed opposite to each other through a sealant, at least two independent liquid crystal seal portions are integrally installed using the electrode substrates and the sealant, and at least one of the seal portions seals different liquid crystals from the other seal portions.

(2) A method of fabricating a liquid crystal display panel comprising the steps of:

disposing a sealant on at least one of electrode substrates that are disposed opposite to each other;

putting a predetermined amount of at least one kind of liquid crystal on the at least one opposite electrode substrate; and

bonding the two electrode substrates in a vacuum state.

(3) The method according to claim 2, wherein the liquid crystal is mixed with spacers and used.

(4) The method according to claim 2, wherein the sealant is formed of ultraviolet (UV) curing resin.

(5) The method according to claim 2, wherein at least a portion of a space between the opposite electrode substrates is sealed with a different sealant from a sealant for bonding so that a difference in pressure between the space and the outside is

generated to pressurize the two electrode substrates.

(6) The method according to claim 2, wherein a space whose one surface is formed of a flexible sheet or film is mechanically sealed by putting the opposite electrode substrates in the space, and a difference in pressure between the space and another space that is separated from the space by the sheet or film is generated to pressurize the two electrode substrates.

(7) The method according to claim 2, wherein the sealant is a double layer of an inner sealant and an outer sealant, the inner sealant being in contact with at least the liquid crystal and formed of UV curing resin, the outer sealant being formed of any one of UV curing resin, thermoplastic resin, and thermosetting resin.

(8) The method according to claim 7, wherein the inner sealant is formed of radical superposition UV curing resin, and the outer sealant is formed of cation polymerization UV curing resin.

(9) A method of fabricating a liquid crystal display panel comprising:

disposing a sealant on at least one of opposite electrode substrates of three or more electrode substrates;

putting a predetermined amount of at least one kind of liquid crystal on the at least one of the opposite electrode substrates; and

bonding the electrode substrates in a vacuum state.

(10) The method according to claim 9, wherein the liquid crystal is mixed with spacers and used.

(11) The method according to claim 9, wherein the sealant is formed of ultraviolet (UV) curing resin.

3. Detailed Description of the Invention

(Technical Field)

The present invention relates to a liquid crystal display (LCD) panel, which is used as an ultrathin, light-weighted, and low-power display, and method of fabricating the same.

(Conventional Arts)

Nowadays, an LCD that is a thin, light-weighted, and low-power display is widely used in various fields, such as an electronic computer, and there is a good likelihood that the LCD will be utilized for more various purposes.

Conventionally, various methods of fabricating the LCD were proposed as follows.

Method (a): At least a required amount of liquid crystal is precisely dropped using a pipette or syringe on one of electrode substrates that are disposed opposite to each other, a third electrode substrate is disposed thereon through spacers in the atmosphere, the liquid crystal filled around the electrode substrates is blown, and an outer circumference of a cell is adhesively sealed using an adhesive.

Method (b): Electrode substrates that are disposed opposite to each other are adhesively fixed to each other using a sealant, and a liquid crystal is injected using capillarity attraction, pressurization, or vacuumization from a liquid crystal injection port, which is previously installed on the electrode substrates, in a sandwich-type cell container that is previously made.

Method (c): As shown in FIGS. 13A through 13D, electrode substrates 1 and 2 that are disposed opposite to each other are adhesively fixed to each other using a sealant 3, a liquid crystal 4 is injected from a previously installed opening using a

vacuum injection method, and an opening is made. In FIGS. 13A through 13D, reference numeral 5 refers to a spacer that serves to maintain a predetermined distance between the electrode substrates 1 and 2, 6 refers to a conductive resin that electrically connects the electrode substrates 1 and 2, and 7 refers to a sealing resin.

(Approaches for Solving the Problems)

However, the above-described conventional methods have the following disadvantages.

First of all, as can seen from Japanese Patent Laid-Open Publication Nos. sho 49-79541, 55-6881, and 55-6882, the method (a) includes a process of discharging air bubbles along with the liquid crystal from a cell without using vacuumization. Thus, it is difficult to control the process, and the air bubbles never fail to remain as might be the case in dropping a fine and precise amount of liquid crystal appropriate for a capacity of the cell. Further, even if a fine amount of liquid crystal is exceeded or a fixed small amount of liquid crystal is always dropped, air bubbles may or may not remain. For this reason, it is necessary to drop a large amount of liquid crystal in order not to leave air bubbles in the cell. Therefore, when the liquid crystal is dropped on the electrode substrate before a sealant is bonded, the sealant flows due to the liquid crystal or the liquid crystal is attached to seal bonding surfaces of the sealant and the electrode substrate. As a result, a selection of sealants is limited and the quality reliability of an LCD panel is degraded. In addition, when the thickness of a previously formed sealant is great, a surplus liquid crystal than the fine needed amount is sealed in the cell before it leaks out. Thus, because a liquid crystal layer cannot obtain a uniform thickness, a seal-type spacer is additionally used and a sealant is

adhesively coated on the outer circumference of the cell in a subsequent process. In this case, in order to improve reliability and operation efficiency, a variety of attempts have been made as proposed in Japanese Patent Laid-Open Publication Nos. sho 51-10711 and 51011934. However, these attempts are undesirable in terms of mass production, because it is required to coat a sealant on an outer circumference of a unit cell and cure the sealant and owing to a great loss in liquid crystal material. As a result, the method (a) is not used at all recently.

Next, as seen from Japanese Patent Laid-Open Publication Nos. sho 49-4648, 49-79541, and 55-6881, the method (b) aims at reliability, operation efficiency, and cost reduction. However, since a process of making a hole in an electrode substrate is necessarily needed, the method (b) increases the cost of production and is disadvantageous in mass production.

For the above-described reasons, the methods (a) and (b) are not used any longer, but only the method (c) is in common use for production of LCD panels.

Nevertheless, even in the method (c) as seen from Japanese Patent Laid-Open Publication Nos. sho 58-37527 and 58-40726, because a surface of an end portion of an injection port is necessarily in contact with a liquid crystal, □ a loss in liquid crystal is incurred to an extent such as adhered to the surface of the end portion of the injection port. □ Also, because a sealant is placed on the surface of the end portion of the injection port, the adhesion of the sealant is degraded and the LCD panel has a poor quality. □ The surface of the end portion of the injection port is in contact with the liquid crystal so that the liquid crystal may be contaminated or covered with dust, thus degrading the quality of the LCD panel. Further, in the method (c), □ it takes quite a long time to inject a liquid crystal. Sometimes, it takes no less than 60 minutes to

fabricate a large-sized panel. □ During injection of liquid crystal, when the electrode substrates are formed of a flexible material, such as a film, they are vertically in contact with each other due to a pressure difference, thus causing a failure in orientation of liquid crystal. □ When an LCD panel is fabricated using a liquid crystal that is mixed with spacers in order to maintain a predetermined distance between electrode substrates, it is impossible to mix the liquid crystal with the spacers beforehand. Instead, it is necessary to scatter the spacers on the entire surface of the electrode substrates before opposite electrode substrates are adhesively fixed to each other. This results in a great waste of high-priced spacer material including a portion adhered to equipment. □ For a multi-layered panel in which two or more cells that use at least one electrode substrate in common overlap in a vertical direction, it is troublesome to fabricate the cells using two or more different kinds of liquid crystals because the different liquid crystals may be mixed with each other. Similarly, for an LCD panel in which two or more cells are connected to each other on the same level, it is not practicable up to now to fabricate cells using two or more different kinds of liquid crystals. This technique has not been proposed yet.

Moreover, except the method (a), each of the methods (b) and (c) involves an electrode substrate bonding process, a liquid crystal pressurization/injection process, and a sealing process.

The present invention, therefore, solves aforementioned problems associated with conventional devices and methods by providing an LCD panel and method of fabricating the same, which incurs no loss in liquid crystal material, prevents contamination of liquid crystal with dust, and simplifies the entire process.

(Summary of the Invention)

In order to accomplish the above objects, a method of fabricating an LCD panel includes disposing a sealant on at least one of electrode substrates that are disposed opposite to each other; putting a predetermined amount of at least one kind of liquid crystal on the at least one opposite electrode substrate; and bonding the two electrode substrates in a vacuum state. Also, an LCD panel uses at least one of two or more electrode substrates in common. In the LCD panel, the electrode substrates are disposed opposite to each other through a sealant, at least two independent liquid crystal seal portions are integrally installed using the electrode substrates and the sealant, and at least one of the seal portions seals different liquid crystals than in the other seal portions.

(Function of the Invention)

According to the structure of the present invention, a predetermined amount of liquid crystal is put on an electrode substrate so that it is adhered only on an inner surface of a cell. Thus, the liquid crystal is adhered neither on a bonding surface between a sealant and the electrode substrate nor outside the sealant. As a result, a high-priced material is not wasted and the adhesion of the sealant can be improved. Also, because only a required amount of liquid crystal is removed from a liquid crystal container onto the electrode substrate, contamination of liquid crystal with dust can be completely prevented. Further, after the liquid crystal is put on the electrode substrate, two or more electrode substrates can be combined rapidly in a vacuum state. Therefore, an electrode substrate bonding process, a liquid crystal injection process, a sealing process, and even a spacer scattering process, if required, can be carried out as a single process in a short duration of time.

In addition, two or more independent liquid crystal seal portions are integrally installed in the structure of the present invention. The seal portions are charged with at least two different kinds of liquid crystals, thus an LCD panel can be fabricated with very high industrial applicability.

(Embodiments)

Hereinafter, exemplary embodiments of the present invention will be described with reference to the accompanying drawings.

[Embodiment 1]

FIGS. 1A through 1C and 2 illustrate a method of fabricating an LCD panel according to an exemplary embodiment of the present invention, and FIGS. 3 and 4 are a perspective view and cross sectional view, respectively, of a vacuum bonder for the method as illustrated in FIGS. 1A through 1C and 2.

At the outset, as shown in FIG. 1A, electrode substrates 11 and 12, which are previously processed and formed of, for example, glass, are prepared to orient liquid crystal molecules. Although not shown in the drawings, patterns are formed on the electrode substrates 11 and 12 using transparent electrodes. For example, a sealant 13, which is formed of UV curing resin made of polyester acrylate augmented with 1 % benzoin ethyl ether, is printed on the electrode substrate 11 using a screen printing process. Also, a conductive resin 14 is printed on the electrode substrate 12 using a screen printing process to electrically connect the upper and lower electrode substrates 11 and 12. In this case, the sealant 13 includes two sealants that are installed as a particle type on the electrode substrate 11, and the conductive resin 14 is printed in a

required position. Next, as shown in FIG. 1B, one or several drops of liquid crystal 15 are dropped near to a central portion of two portions of the electrode substrate 11 that are surrounded by the sealant 13. In this case, the liquid crystal 15 may be mixed with spacers 16 to maintain a predetermined distance between the opposite substrates 11 and 12 as described below. However, the liquid crystal 15 without containing the spacers 16 may be dropped.

The liquid crystal 15 is dropped using a microsyringe and its drop amount is controlled within ±7% of fine amount. In this case, when the portion of the electrode substrate 11 on which the liquid crystal 15 is dropped is too close to the sealant 13, the liquid crystal 15 may flow to the sealant 13 before the electrode substrates 11 and 12 are bonded to each other. Thus, when the electrode substrates 11 and 12 are bonded to each other, the sealant 13 may be cut or the liquid crystal 15 may overflow out of the sealant 13. Also, when the number of drops of liquid crystal 15 is small, a liquid crystal layer is easily formed to a non-uniform thickness (hereinafter, a gap) on the portion where the liquid crystal 15 is dropped or the other portion. Therefore, it is desirable to uniformly drop many drops of liquid crystal 15 if possible. In addition, the precision of amount of liquid crystal 15 reflects the precision of the gap.

Accordingly, process conditions should be determined in consideration of the shape, size, and gap precision of an LCD panel to be fabricated. For example, when a liquid crystal seal portion has a size of 33mm×17mm×9.0μm, the liquid crystal 16 overflows out of the seal portion in a wide range, as might be the case in dropping a drop of liquid crystal 15 (5.05μℓ) on the center of the seal portion, and is desirably injected without overflow, as might be the case in dropping three smaller drops of liquid

crystal 15 at regular intervals in a lengthwise direction of the seal portion. Also, the above-described range (±7%) of fine amount within which a drop amount of liquid crystal 16 is controlled is obtained from various experiments, but the present invention is not limited thereto.

After the liquid crystal 15 is dropped, as shown in FIG. 1C, the two electrode substrates 11 and 12 are bonded in vacuum. However, before the electrode substrates 11 and 12 are bonded, as shown in FIG. 2, the electrode substrates 11 and 12 overlap using a 1-㎜ assembling spacer 17 such that electrode patterns are aligned.

Subsequently, the overlapped electrode substrates 11 and 12 are put in a space (concave portion) 20 formed in a base 19 of a vacuum bonder 18 as shown in FIGS. 3 and 4, the space 20 is covered with a sheet 21 formed of, for example, silicon rubber, and the space 20 is closed with a covering 22 and the covering 22 is fixed with a bolt (not shown). Also, a space 23 as shown in FIG. 4 is vacuumized using a vacuum pump (not shown) that contacts an exhaust port 24, and the space 20 in which the electrode substrates 11 and 12 are put is vacuumized using a vacuum pump (not shown) that contacts an exhaust port 25. Here, although the degree of vacuum depends on the shape and size of an LCD panel to be fabricated, in the present embodiment, when the degree of vacuum in the space 20 is 10^{-1} torr or lower, the vacuumization of the space 23 is stopped, and air is gradually leaked through the exhaust port 24 using a leak valve (not shown). In order to prevent degradation of liquid crystal 15, it is more desirable to leak a nitrogen gas.

During the air leak, the sheet 21 formed of silicon rubber becomes slack downward, and the electrode substrates 11 and 21 are generally pressurized due to the atmosphere. Thereafter, a handle 26 is wheeled to remove the assembling spacer 17,

and the leak valve is completely opened until the space 23 is under an atmospheric pressure (1-pressure). At this time, the electrode substrates 11 and 12 are completely pressurized and bonded to each other in vacuum, and the liquid crystal 15 is divided into two parts and sealed by the sealant 13 between the electrode substrates 11 and 12. Also, when the electrode substrates 11 and 12 are insufficiently pressurized, a high-pressure nitrogen gas or air can be supplied through the exhaust port 24.

Thereafter, the vacuumization of the space 20 is stopped, and the space 20 is restored to a leak atmospheric pressure through the exhaust port 26. Similarly, it is more desirable to leak a nitrogen gas to prevent degradation of liquid crystal 15. After that, the covering 22 is opened, the bonded electrode substrates 11 and 12 are extracted from the space 20, and the sealant 13 is cured.

Thereafter, the electrode substrates 11 and 12 are cut to a predetermined size, thus the LCD panel is completed as shown in FIG. 5.

In the present embodiment, it is described that the curing of the sealant 13 is performed outside the vacuum bonder 18, but the sealant 13 may be cured inside the vacuum bonder 18. However, experiments show that when the sealant 13 is cured while pressurizing the electrode substrates 11 and 12, the gap in the LCD is more uniform than when the electrode substrates 11 and 12 are not pressurized. Also, it is described in the present embodiment that the entire electrode substrates 11 and 12 are uniformly pressurized in the vacuum bonder 18, but they may be partially pressurized. For example, only the sealant 13 may be pressurized. Also, when the pressurization of the electrode substrates 11 and 12 is performed using a pressure difference, which is frequently considered as a pressurization method, a flexible film formed of silicon rubber or a sheet type material can be used for sufficient pressurization. Moreover, if

at least part of space between the electrode substrates 11 and 12 is maintained under a lower pressure than an external pressure using other sealant than the sealant 13, the electrode substrates 11 and 12 can be pressurized without even a weight (a pressing unit). This method may be applied to conventional methods including bonding the electrode substrates 11 and 12 beforehand and then injecting a liquid crystal. In particular, when both the sealant 13 and an additional sealant are formed of UV curing resin, the method is very effective because the weight (or pressing unit) does not intercept UV light and UV irradiation is simple.

Further, in the present invention, when the electrode substrates 11 and 12 are bonded using the sealant 13 in vacuum, the liquid crystal 15 need to be sealed therein at the same time. Also, the sealant 13 should be cured with the liquid crystal 15 sealed, so that a uniform gap can be obtained. For these reasons, it is difficult to treat such materials as thermosetting resin and thermoplastic resin that need to be heated when they are bonded or cured. On the contrary, since UV curing resin is cured at a normal temperature in a small amount of time and has a long photolight, it is quite appropriate for the sealant 13 for the present invention.

In the present embodiment, radical superposition polyester acrylate is used as UV curing resin. In addition to radical superposition polyester acrylate, radical polymerization resin, such as epoxy acrylate and urethane acrylate, may be used without adversely affecting the liquid crystal 15. When the radical polymerization resin is used, the resultant LCD panel can be employed without causing problems under typical conditions. However, when the LCD panel is employed under strict temperature and humidity conditions, it does not withstand heat and moisture very well.

Meanwhile, cation polymerization UV curing resin increases the amount of

consumed current of liquid crystal 15 but withstands heat and moisture very well. Therefore, an outer sealant is formed of the cation polymerization UV curing resin and an inner sealant that contacts the liquid crystal 15 is formed of radical superposition resin, so that a double sealant is formed. As a result, an LCD panel can be fabricated with high reliability and high quality. Also, it is obvious that the outer sealant can be formed of thermosetting resin that is heat-resistant and moisture-proof. In making use of the double sealant, it is preferable that radical superposition UV curing resin (the sealant 13 of the present embodiment) be installed as the inner sealant on the electrode substrate 11 on which the liquid crystal 16 is dropped, and cation polymerization UV curing resin or thermosetting resin be installed as the outer sealant on the other electrode substrate 12. In this case, the outer sealant is installed outside the inner sealant.

The double sealant using the UV curing resin can greatly reduce a time taken to cure the sealant in comparison to a double sealant using thermosetting resin or thermoplastic resin. Also, even if one of the inner and outer sealants is formed of thermosetting resin that takes a long time to cure, when both the inner and outer sealants are formed of thermosetting resin, it is necessary to pressurize the electrode substrates 11 and 12 until the sealant is cured in order to uniformize the gap. However, when one of the inner and outer sealants is formed of UV curing resin that takes a short time to cure, after the sealant is cured, the gap does not change. Therefore, it is not necessary to pressurize the electrode substrates 11 and 12 at all. In addition, the double sealant can be desirably applied to the conventional methods including bonding the electrode substrates beforehand and then injecting a liquid crystal for the same reason as described above.

In order to form the double sealant, it is preferable that at least one of outer

sealant, inner sealant, and conductive resin be formed to a fixed amount using an ejection method instead of a screen printing method.

Also, in the present invention, glass substrates are used as the electrode substrates 11 and 12. However, the electrode substrates 11 and 12 may be formed of a flexible material, such as a film, if and only if a new method is invented such that the electrode substrates 11 and 12 do not come into contact with each other before they are adhesively pressurized in the vacuum bonder 18.

[Embodiment 2]

As shown in FIG. 7, a trilayer guest-host-type LCD panel shown in FIG. 8 is fabricated using total four substrates in the same manner as in the first embodiment. A predetermined electrode pattern (not shown) is formed on both sides of each of two electrode substrates 28a and 28b, and a predetermined electrode pattern (not shown) is formed on only one side of each of two electrode substrates 28 and 29. Also, respective liquid crystals 30, 31, and 32 are different and contain red, blue, and yellow pigments, respectively. In a conventional method, liquid crystals are mixed, or while a liquid crystal is being injected into a first layer, injection ports of the other layers are stopped. However, according to the present embodiment, those problems do not happen in the least. Also, it is obvious that a more multilayered LCD panel can be fabricated according to the present invention

[Embodiment 3]

As shown in FIG. 9, an LCD panel as shown in FIG. 10 is fabricated in the same manner as in the first embodiment. In the present embodiment, the LCD panel

includes 81 liquid crystal seal portions and is fabricated using three kinds of liquid crystals 30, 31, and 32, which contain red, blue, and yellow pigments, respectively, as in the second embodiment. Conventionally, it is impossible to fabricate this kind of LCD panel. In other words, it was substantially hard to make a hole in a portion of an electrode substrate that corresponds to each cell, and this technique has not been proposed for the reason that an injection port disposed in a display portion may damage the image of the LCD panel. In FIGS. 9 and 10, reference numerals 34 and 35 denote electrode substrates, and 36 denotes a sealant for 81 liquid crystal seal portions.

[Embodiment 4]

As shown in FIG. 11, an LCD panel is fabricated in the same manner as in the first embodiment. In the present embodiment, a single large-sized electrode substrate 37 and three small-sized electrodes 38, 39, and 40 are used, and three liquid crystal seal portions are disposed in the center of sealants 41, 41a, and 41b, respectively. In this case, one kind of liquid crystal 42 is injected into the three liquid crystal seal portions. Like in the third embodiment, the LCD panel of the present embodiment also was substantially hard to fabricate and has not been proposed.

Also, in the present invention, it is obvious that the diameter of spacer in the sealant may be different in respective cells, a distance between electrode substrates may be different in the respective cell, and a viewing angle may be different in the respective cells depending on a different combination of orientation and twist direction of liquid crystal.

(Effects of the Invention)

As described above, the present invention has the following merits. Above all, because a required amount of liquid crystal is directly put on an electrode substrate from a liquid crystal container, □ a loss in high-priced liquid crystal material is not incurred. □ Contamination of liquid crystal with dust is prevented. □ Since a liquid crystal is adhered neither on a sealant nor on a seal adhering portion of the electrode substrate, adhesion of the sealant is becomes better. □ A failure in a seal portion does not happen because there is no injection port for a liquid crystal. Also, □ after the liquid crystal is put on the electrode substrate, two or more electrode substrates can be bonded to each other rapidly in a vacuum state. Thus, an electrode substrate bonding process, a liquid crystal injection process, a sealing process, and even a spacer scattering process, if required, can be carried out as a single process in a short duration of time. □ An expensive spacer material is not wasted at all. □ Further, when the sealant is formed of UV curing resin, the number of days for the entire process operations (from a substrate cleaning operation to a finished product inspection process) can be greatly reduced from 3 or more to less than 1.

Furthermore, □ the present invention can provide an utterly new type of LCD panel in which two or more independent liquid crystal seal portions are integrally installed and charged with at least two different kinds of liquid crystals, as has not been introduced yet. In addition, □ even a multilayered LCD panel can be easily produced without mixing different liquid crystals.

Brief Description of the Drawings

FIGS. 1A through 1C are perspective views illustrating a method of fabricating a liquid crystal display (LCD) panel according to an exemplary embodiment of the

present invention;

FIG. 2 is a cross sectional view corresponding to FIG. 1;

FIG. 3 is a perspective view of a vacuum bonder for the method of the present invention;

FIG. 4 is a cross sectional view corresponding to FIG. 3;

FIG. 5 is a top view of an LCD panel that is fabricated by the method of the present invention;

FIG. 6 is a cross sectional view corresponding to FIG. 5;

FIG. 7 is a perspective view illustrating a method of fabricating an LCD panel according to another exemplary embodiment of the present invention;

FIG. 8 is a perspective view of the LCD panel that is completed according to the method shown in FIG. 7;

FIG. 9 is a perspective view illustrating a method of fabricating an LCD panel according to yet another exemplary embodiment of the present invention;

FIG. 10 is a perspective view of the LCD panel that is completed according to the method shown in FIG. 9;

FIG. 11 is a perspective view illustrating a method of fabricating an LCD panel according to further another exemplary embodiment of the present invention;

FIG. 12 is a perspective view of the LCD panel that is completed according to the method shown in FIG. 11; and

FIGS. 13A through 13D are perspective views illustrating a method of fabricating a conventional LCD panel.

<Explanation of Reference numerals>

11, 12, 28, 28a, 29, 29a, 34, 35, 37, 38, 39, and 40: electrode substrate

13, 33, 33a, 33b, 36, 41, 41a, and 41b: sealant

15, 30, 31, 32, and 42: liquid crystal

16: spacer